Updated National Action Plan upon Stress-Test Results

State Nuclear Regulatory Inspectorate of Ukraine

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INTRODUCTION

In June 2011, Ukraine joined the European initiative of conducting stress tests at nuclear power plants in EU member states and neighboring countries (Stress Test Declaration). The stress tests were focused on:

- Zaporizhzhia NPP units 1-6 (VVER-1000/320) and dry spent nuclear fuel storage facility (DSF) located on the Zaporizhzhia NPP site;
- Rivne NPP units 1, 2 (VVER-440/213) and units 3, 4 (VVER-1000/320);
- PNPP unit 1 (VVER-1000/302), unit 2 (VVER-1000/338) and unit 3 (VVER-1000/320);
- Khmelnytsky NPP units 1, 2 (VVER-1000/320);
- Chornobyl NPP units 1-3 (spent fuel pools) and interim spent fuel storage facility (ISF-1) located on the Chornobyl NPP site.

The National Action Plan was developed at the beginning of 2013 to implement recommendations of the peer review of stress tests at Ukrainian NPPs and to ensure that the operating organizations take safety improvements identified upon stress tests and the SNRIU efficiently monitors this process.

The National Action Plan was updated on a regular basis in 2015, 2017, 2020, and 2021. The status of safety improvement measures and the schedule for implementation of individual measures were specified to update (2023) the National Action Plan. The number of planned measures and their scope remained unchanged.

Part I “Safety Improvement Measures” of the updated National Action Plan provides a list of measures of the National Action Plan upon Stress-Test Results (2013) both for the operating NPPs and Chornobyl NPP with renewed information on the current status and schedule of measures.

Part II “Status of Safety Improvement Measures” of the updated National Action Plan presents more detailed information on the updating, specifically: a brief description of the planned scope for implementation, status of implementation (more detailed information is provided for completed measures) and corrected schedule are provided for each measure.

Implementation of the safety improvement measures defined in the National Action Plan is a priority for the Energoatom operating organization. Because of the situation in Ukraine in recent years (in particular, full-scale invasion of russia to Ukraine) that complicated/delayed the implementation of individual measures), the timeframes for individual safety improvement measures at operating NPPs requiring significant engineering and research efforts have been extended.

Currently, about 85% of the safety improvement measures planned in compliance with the updated National Action Plan have been implemented. In addition, it should be noted that all measures specified upon stress tests at the Chornobyl NPP have been implemented in full.

ABBREVIATIONS

C(I)SIP	Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs
ChNPP	State Specialized Enterprise 'Chornobyl NPP'
CLMS	Coolant Level Monitoring System
DG	Diesel Generator
EC	European Commission
ECR	Emergency Control Room
Energoatom	National Nuclear Operator 'Energoatom'
EOP	Emergency Operating Procedure
EU	European Union
IAEA	International Atomic Energy Agency
ISF	Interim Spent Fuel Storage Facility
KhNPP	Khmelnytsky Nuclear Power Plant
MCR	Main Control Room
NPP	Nuclear Power Plant
PAMS	Accident and Post-Accident Monitoring System
PNPP	Pivdennoukrainsk Nuclear Power Plant
PSA	Probabilistic Safety Assessment
RNPP	Rivne Nuclear Power Plant
SAMG	Severe Accident Management Guideline
SFA	Spent Fuel Assembly
SFP	Spent Fuel Pool
SG	Steam Generator
SSE	Safe Shutdown Earthquake
UARMS	Unified State Automated Radiation Monitoring System in Ukraine
VS	Ventilation Stack
VVER	Water-Cooled Water-Moderated Power Reactor
ZNPP	Zaporizhzhia Nuclear Power Plant

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PART I. SAFETY IMPROVEMENT MEASURES

Table 1.1 Measures Identified upon Stress Tests at Operating NPPs

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				VVER-440/213	VVER-1000/320	VVER-1000/302, 338
	Natural Hazards					
1.	Equipment qualification (harsh environments and seismic* impacts)	(5), (6), (11), (13)	[1], [2]	completed/ completed	completed/ 2025 ongoing	completed/ completed
2.	Seismic resistance of structures, systems and components important to safety	(5)	[1], [2]	2025/2025 ongoing	completed/ 2025 ongoing	completed/ completed
3.	Consideration of a full range of initiating events for all reactor and SFP states in PSA	(5)	[1], [2]	2025/2025	completed/ 2025	2025/2025
4.	Implementation of a seismic monitoring system at NPP sites	(10)	[1], [2]	completed		
	Loss of Safety Systems (Loss of Power and/or Ultimate Heat Sink)					
5.	SFP makeup and cooling in long-term station blackout conditions	(14), (17), (23), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
6.	SG makeup and cooling in long-term station blackout conditions	(14), (17), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
7.	Improved reliability of emergency power supply	(15), (16), (17), (18), (22), (24), (26), (27), (28)	[1], [2]	–	–	completed/ completed
8.	Emergency power supply in long-term loss of power	(15), (16), (17), (18), (22), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ 2025 ongoing	–
9.	Functionality of group A equipment fed from the service water system in case of water discharge in spray ponds	(17), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ completed	–
10.	Functionality of group A equipment fed from the service water system in case of failure of ventilation cooling towers and/or service water supply pumps	(17), (24), (26), (27), (28)	[1], [2]	–	–	completed/ completed

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				VVER-440/213	VVER-1000/320	VVER-1000/302, 338
11.	Provision of instrumentation during and after accidents (accident and post-accident monitoring system)	(18)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
12.	Development, technical justification, validation and implementation of symptom-oriented EOPs for management of design-basis and beyond design-basis accidents (low power and shutdown states)	(19), (23)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
13.	Detailed analysis of primary system makeup in case of loss of power and/or ultimate heat sink	(20)	[1], [1]	completed	completed	completed
14.	Replacement of self-contained air conditioners by those qualified for harsh environments and seismic impacts	(22)	[1], [2]	completed/ completed	completed/ 2025 ongoing	completed/ completed
15.	Habitability of MCR and ECR in design-basis and beyond design-basis accidents (installation of iodine filters)	(22)	[1], [2]	completed	–	–
Severe Accident Management						
16.	Severe accident analysis. SAMG development	(39), (41)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
17.	Prevention of early containment bypassing in case of molten corium spread to the containment	(31), (32)	[1], [2], [1]	–	completed/ completed	completed
18.	Implementation of a containment hydrogen control system for beyond design-basis accidents	(31), (32), (41), (11)	[1], [2]	completed	completed/ completed	completed/ completed
19.	Development and implementation of hydrogen mitigation measures for beyond design-basis accidents	(31), (32), (41)	[1], [2]	2025/2025 ongoing	completed/ completed	completed/ completed
20.	Implementation of a containment venting system	(31), (32), (41)	[1], [2]	2025/2025 ongoing	completed /2024 ongoing	completed/ completed
21.	Analysis of the strategy for possible corium confinement within the reactor pressure vessel	(31), (32)	[1], [1]	completed	2025 ongoing	2025 ongoing
22.	Analysis of the need and possibility to qualify power unit components that may be involved in severe accident management for harsh environments	(31), (32), (33)	[1], [1]	2025 ongoing	2025 ongoing	2025 ongoing
23.	Detailed analysis and development of conceptual solutions on	(42)		2024	2024	2024

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				VVER-440/213	VVER-1000/320	VVER-1000/302, 338
	management with large volumes of contaminated water			ongoing	ongoing	ongoing
24.	Seismic evaluation of buildings and systems of the on-site emergency center and their robustness in severe accident conditions	(43), (44)		completed		
25.	Analysis of severe accident phenomena based on available experimental data and improvement of computer models	(44)	(5)	2026 ongoing	2026 ongoing	2026 ongoing
Additional Topics and Activities						
26.	Harmonization of Ukrainian nuclear and radiation safety regulations with WENRA reference levels: a) self-assessment; b) development of a harmonization action plan	(31)		completed		
27.	Self-assessment of the nuclear safety regulation system using the new IAEA instrument – SARIS	(103)		completed		
28.	Provision of mobile laboratories to ZNPP and PNPP	(110)		PNPP – completed, ZNPP – currently 2025 (new deadline will be established after de-occupation)		
29.	Development of the concept and plan for the unified state automated radiation monitoring system of Ukraine (UARMS)	(110), (114), (120)		2022 completed [6]		
30.	Long-term (more than 24 hours) emergency training for all response parties, including central executive authorities, to test the knowledge transfer procedure in conditions of shift work of emergency staff	(113)		conducted annually during general plant training		
31.	Implementation of the RODOS system	(115)		2017 completed		
32.	Modernization of the SNRIU Emergency Response and Information Centre	(121)		2017 completed		
33.	Implementation of a reactor pressure vessel external cooling system	(31), (32)	[1], [1]	2025/2025 ongoing	-	-

Table 1.2 Measures Identified upon Stress Tests at Chornobyl NPP

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Status	Schedule
1.	Installation of an additional level control device in 1 (2) fuel assembly cooling pools-1, 2 for emergencies related to level water decrease below marks 19, 22	(18)	[3], [4]	completed	2012
2.	Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under loads induced by a tornado of class F 3.0	(13)	[3], [4]	completed	2016
3.	Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under seismic loads	(13)	[3], [4]	completed	2015
4.	Seismic resistance analysis of ISF-1 SFP lining	(23), (30)	[3], [4]	completed	2015
5.	Analysis of stability and potential failures of VS-1 under SSE and tornado	(23), (30)	[3], [4]	completed	2014
6.	Nuclear safety justification for the spent fuel pools of units 1, 2 with 250×110 mm arrangement of SFAs (as reserve for one ISF-1 compartment)	(23), (30)	[3], [4]	completed	2012
7.	Justifying calculation of the maximum fuel cladding temperature taking into account potential radiological consequences from wet SFA storage	(23), (30)	[3], [4]	completed	2013
8.	Development of an action plan to improve the emergency preparedness system in case of beyond design-basis accidents caused by natural hazards, including emergency response measures in case of damage of the building and leakage of SFP	(26), (28), (34), (38), (39)	[3], [4]	completed	2012
9.	Amendment of the ChNPP accident and emergency response plan (32P-S) to improve emergency preparedness	(26), (28), (34), (37), (39)	[3], [4]	completed	2012
10.	Development of measures on prompt access of emergency teams from Slavutych by alternative routes in case of damage of Slavutych–ChNPP railroad tracks caused by SSE	(34)	[3], [4]	completed	2012
11.	Modernization of the ISF-1 radiation monitoring system to ensure neutron flux density monitoring	(18), (30)	[3], [4]	completed	2012
12.	Additional radiation monitoring of exposure dose rate of the container car in ISF-1 during spent fuel transport	(18)	[3], [4]	completed	2012
13.	Replacement of the UDZhG-04R detector with an RWM-02 detector for the instrumentation channel for monitoring the activity concentration of service water after heat exchangers in ISF-1 spent fuel pools	(18)	[3], [4]	completed	2013
14.	Power supply to ISF-1 essential equipment fed from mobile DG	(15), (16), (26)	[3], [4]	completed	-
15.	Purchase of a new container car for SFA transport	(30)	[3], [4]	completed	2018

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Status	Schedule
16.	Revision of the ISF-1 safety improvement plan	(23), (30)	[3], [4]	completed	2012
17.	Introduction of the topic “multiple failures of regular systems and equipment in severe weather conditions” into the 2012 training program for ChNPP staff of certain positions for detailed theoretical elaboration of the training scenario	(26), (28), (34), (108)	[3], [4]	completed	2012
18.	Introduction of the topic “multiple failures of regular systems and equipment in severe weather conditions” into the 2012 training program (Section 14) for practical exercise by staff of all shifts	(26), (28), (34), (108)	[3], [4]	completed	2012
19.	Psychological training of staff intended to increase resilience to psychological stress, develop self-control, composure and promote mutual aid and cooperation	(38), (122)	[3], [4]	completed	2012
20.	Implementation of a system for psychological selection and training of individuals involved in severe accident management, similar to the system for selection of operating personnel	(38)	[3], [4]	completed	2012

References

1. Comprehensive (Integrated) Safety Improvement Program (C(I)SIP), approved by Cabinet Resolution No. 1270 dated 7 December 2011.
2. SNRIU Board Resolution No. 13 dated 24-25 November 2011 “On results of the targeted safety reassessment of operating NPPs and ZNPP dry spent fuel storage facility in the light of the events at Fukushima-1”.
3. SNRIU Board Resolution No. 12 dated 3 November 2011 “On result of the targeted safety reassessment of Chornobyl NPP units 1-3 and Interim Spent Nuclear Fuel Storage Facility in the light of the events at Fukushima-1”.
4. Safety Improvement Plan for ChNPP Nuclear Installations.
5. SNRIU Board Resolution No. 14 dated 20 November 2012 “On the progress in implementation of measures based on stress-tests results for operating NPPs”.
6. Cabinet Resolution No. 323-r dated 29 April 2022. On Approval of the Strategy for the Integrated Automated Radiation Monitoring System for the Period by 2024.

Part II. Status of Safety Improvement Measures

Section 1. Status of Measures Identified upon Stress Tests at Operating NPPs

This Section provides information on the status of measures identified upon stress tests at the operating NPPs and presented in Table 1.1 of Part IV "Plan for Implementation of Safety Improvements" of the National Action Plan upon Stress-Test Results (2013).

Area: Natural Hazards

Item 1. "Equipment qualification (harsh environments and seismic impacts)"

This measure is intended to confirm the operability of NPP systems and components and their capability to perform safety functions under seismic events and harsh environments (high temperature, pressure, radiation, moisture etc.) that may occur in design-basis accidents. Unqualified equipment must be replaced or necessary compensatory measures must be implemented.

The initial data on equipment qualification at all NPP units have been agreed by the SNRIU.

Measure has been completed for ZNPP-1,2,3,4,5; RNPP-1,2,3,4; KhNPP-1,2; PNPP-1,2,3.

Schedule for ZNPP-6: 2025. (Postponed because of ZNPP occupation). Currently, the electrical equipment and equipment of instrumentation and control systems has been qualified for seismic impacts. The activities related to the qualification of equipment for harsh environments and qualification of thermal and mechanical equipment for seismic impacts were suspended and will be continued after ZNPP de-occupation.

Item 2. "Seismic resistance of structures, systems and components important to safety"

Stage 1: This measure is intended to ensure resistance to earthquakes of at least 7 magnitudes on the MSK-64 scale (but not less than 0.1 g peak ground acceleration) for equipment, piping, buildings and structures required to perform critical safety functions (provide for safe reactor shutdown and keep the reactor in safe state, remove heat from the reactor core and spent fuel pool, prevent radioactive releases to the environment).

The input data for assessing the seismic resistance of equipment, piping, buildings and structures of all NPP units have been agreed by the SNRIU.

Stage I of the measure (seismic resistance assessment not considering the results of seismic monitoring) **has been completed for ZNPP-1,2,3,4,5; RNPP-1,2,3,4; KhNPP-1,2; PNPP-1,2,3.**

Activities on Stage I (assessment and compensatory measures) for ZNPP-6 were postponed until 2025 because of ZNPP occupation.

Stage II: seismic resistance assessment upon seismic monitoring (if necessary).

The measure has been completed for ZNPP-1,2,3,4,5 and PNPP-1,2,3.

Schedule: ZNPP-6, RNPP-1-4 and KhNPP-1,2 – 2025 (Postponed because of the full-scale invasion of russia)

Item 3. "Consideration of a full range of initiating events for all reactor and SFP states in PSA"

This measure involved probabilistic safety assessments of levels 1 and 2 for a full range of initiating events (including natural hazards) for all regulated states of the power unit, covering both the reactor core and spent fuel pool.

The measure has been completed for all NPP power units: ZNPP-1-6; RNPP-1-4; KhNPP-1-2; PNPP-1-3.

PSA for seismic events is performed in the framework of individual C(I)SIP measures No. 19106, 29106, and 39106.

Measure No. 19106 has been completed at pilot ZNPP-1 and ZNPP- 2,3.
Schedule for other power units:
ZNPP-4: 2023. The reports have been developed and passed state review on nuclear and radiation safety and are under revision to incorporate comments of the state review;
ZNPP-5: 2024; The reports have been developed, passed state review on nuclear and radiation safety and are under revision to incorporate comments of the state review.
ZNPP-6; RNPP-1,2,3,4; KhNPP-1,2; PNPP-1,2,3: 2025.

Item 4. "Implementation of a seismic monitoring system at NPP sites"

This measure is intended to implement systems for continuous seismic monitoring in order to determine actual seismic characteristics of NPP sites. The monitoring results and numerical parameters for predicted seismic events should be used to plot new accelerograms and obtain ground response spectra for the design-basis earthquake (DBE) and safe shutdown earthquake (SSE).

T**he measure has been completed for all sites** (**PNPP, KhNPP, ZNPP and RNPP).**

Area: Loss of Safety Functions (Loss of Power and/or Ultimate Heat Sink)

Item 5. "SFP makeup and cooling in long-term station blackout conditions"

This measure is intended to ensure SFP emergency makeup through a series of actions to connect a mobile pumping unit to restore forced water circulation in SFP with boric acid solution from tanks and emergency makeup of SFP from on-site water supply sources. It is needed to:

- perform calculations to justify characteristics of the mobile pumping unit (MPU) to ensure SFP makeup during the time required to restore design-basis systems;
- supply equipment;
- install special-type connectors to enable connection of MPU hydrants to on-site water supply sources and pressure piping of the SFP cooldown system and/or piping of emergency SFP makeup from the spray system;
- develop and introduce emergency procedures for use and connection of MPUs.

The measure has been completed at all power units: ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; PNPP-1,2,3; KhNPP-1,2.

Item 6. "SG makeup and cooling in long-term station blackout conditions"

This measure is intended to connect mobile units to supply feedwater to SG and requires to:

- analyze potential water discharge to SG from turbine compartment deaerators at the maximum flow rate in long-term station blackout conditions;
- supply equipment;
- take actions to connect MPU for emergency SG makeup from on-site water sources, including:
  - calculations to justify MPU characteristics;
  - installation of special-type connectors to enable connection of MPU to any on-site water source and to the pressure side of the SG emergency makeup system;
  - development and implementation of emergency procedures for use of MPU for SG makeup and emergency heat removal from the core through SG.

Potential recriticality and coolant leak through the main coolant pump sealing shall be taken into account in implementation of the measure.

The measure has been completed at all power units: ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; PNPP-1,2,3; KhNPP-1,2.

Item 7. "Improved reliability of emergency power supply (PNPP-1,2)"

Item 8. "Emergency power supply in long-term loss of power (other power units)"

This measure is intended to take a series of actions to connect a mobile diesel generator to recover power supply to systems that can be used to inject water to the primary side and spent fuel pools, as well as to monitor and perform critical safety functions, ensure remote control of valves and emergency lighting, including:

- calculations to justify characteristics of the mobile diesel generator;
- equipment supply;
- connection of the mobile diesel generator to buses of the emergency power supply system of category 1 to energize design-basis pumps for high-pressure emergency boron injection, SFP cooldown pumps, uninterruptible power supply sources and systems required for monitoring of emergency processes;
- development and implementation of emergency procedures for use of the mobile diesel generator.

The measure has been completed for ZNPP-1,2,3,4,5; RNPP-1,2,3,4; KhNPP-1,2; PNPP-1,2.

ZNPP-6: a 0.4 kV mobile DG was purchased and connected according to non-regular scheme to safety system busbars). The 0.4 kV mobile DG is planned to be connected at ZNPP-6 according to regular scheme in **2025 (Postponed because of ZNPP occupation).**

For PNPP-3, a 0.4 kV mobile DG was purchased and connected according to the regular scheme. The installed equipment provides power supply to:

– 0.4 kV buses of safety systems, uninterruptible power supply units of safety systems-1,2,3; uninterruptible power supply units of control safety systems;

- chargers of storage batteries for safety systems;

- pumping unit for SFP cooling, pumping unit for emergency high-pressure boron injection, compressor unit, life support ventilation units for MCR.

The implementation of the measure ensures power supply to systems that can create the subcriticality necessary to start reactor cooling and supply cooling water to remove heat from SFP. According to the technical specifications, uninterruptible operation of the mobile DGs lasts at least 72 hours considering fuel refilling.

According to the SNRIU comments, a backup connection point for mobile DGs was arranged during refueling outage-2023. Completion is planned for 2023.

Item 9. "Functionality of group A equipment fed from the service water system in case of water discharge in spray ponds"

This measure is intended to take a series of actions for emergency supply of service water to essential loads by a mobile pumping unit from the NPP circulation water cooling system or other available water sources including:

- determination of an optimal list of loads that require emergency supply of service water from the mobile pumping unit (MPU);

- calculation to justify MPU characteristics to ensure water supply within the period required to restore operation of design-basis systems;
- equipment supply;
- development and implementation of emergency procedures for MPU use and connection.

This measure is not envisaged for PNPP-1, 2 (VVER-1000/302, 338) since their design includes ventilation cooling towers instead of spray ponds (see the measure in item 10).

The measure has been completed at all power units: ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; KhNPP-1,2; PNPP-3.

Item 10. "Functionality of group A equipment fed from the service water system in case of failure of ventilation cooling towers and/or service water supply pumps"

This measure is intended to take a series of actions to provide cooling water to standby DGs, equipment and mechanisms needed for reactor cooldown in loss of normal power supply buses and failure of essential service water supply system.

The measure was completed for PNPP-1,2.

Item 11. "Provision of instrumentation during and after accidents (accident and post-accident monitoring system)"

This measure is intended to:

- install features to monitor coolant overheating at fuel assembly outlet, under the reactor head assembly and in hot legs of reactor coolant piping within an extended temperature range;
- introduce features to monitor coolant level above the core in emergencies;
- install features to monitor hydrogen concentration in the containment during accidents;
- conduct additional analysis to determine the minimum required list of signals for accident and post-accident reactor monitoring;
- introduce emergency instrumentation with an extended measurement range for monitored process parameters;
- introduce a data storage system for conditions of design-basis and beyond design-basis accidents (black box).

The measure has been completed at all power units: ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; KhNPP-1,2; PNPP-1,2,3.

Item 12. "Development, technical justification, validation and implementation of symptom-oriented EOPs for management of design-basis and beyond design-basis accidents (low power and shutdown states)"

The measure has been completed at all power units: **ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; KhNPP-1,2; PNPP-1,2,3** (symptom-based EOPs for low power and shutdown states have been developed and implemented).

Item 13. "Detailed analysis of primary system makeup in case of loss of power and/or ultimate heat sink".

A detailed and comprehensive analysis of the need for makeup of the primary system in case of accidents involving loss of power supply and/or ultimate heat sink was carried out. The analysis addressed potential accident progression scenarios in which loss of power and cooling water will make

primary system makeup impossible. Hence, the use of mobile sources for primary system makeup was considered as a compensatory measure. The reports were agreed with the SNRIU.

The analysis for VVER-440 units determined that the existing regular safety systems and other technical features energized by 0.4 kV mobile DGs could be used for cooldown and replenishing of the primary system coolant, and service water could be supplied by the mobile pumping unit.

Based on the analysis, recommendations for optimizing the layout and deployment time of non-design equipment (mobile pumping unit, mobile diesel generators) and installing an additional pumping unit for makeup of the primary system were determined for VVER-1000 units. A concept for implementing a new technical measure is under development.

VVER-440 (V-213): the measure was completed in 2016.

VVER-1000 (V-302, 338, 320): the measure was completed in 2023.

The measure has been completed for all reactor types.

Item 14. "Replacement of self-contained air conditioners by those qualified for harsh environments and seismic impacts"

The measure has been completed for ZNPP-1,3,4,5; PNPP-1,2,3; RNPP-1,2,3,4; KhNPP-1,2.

Schedule for ZNPP-2,6: 2025 (Postponed because of ZNPP occupation).

Item 15. "Habitability of MCR and ECR in design-basis and beyond design-basis accidents (installation of iodine filters)".

This measure was intended only for VVER-440/213 power units.

The measure was completed (2011 – RNPP-1; 2012 – RNPP-2).

Area: "Severe Accident Management"

Item 16. "Severe accident analysis. SAMG development"

This measure is intended to develop severe accident management guidelines for operation at rated power as well as for low power and shutdown states. The guidelines shall be aimed at severe accident management both in the reactor core and spent fuel pool.

The measure has been completed for all NPP units.

Item 17. "Prevention of early containment bypassing in case of molten corium spread to the containment".

PNPP-1,2: measure has been completed (appropriate analytical justifications were developed, enclosing concrete structure was installed on the way of potential corium spread, operating documentation was amended, in particular, regarding the position of doors in the lower part of the reactor concrete vault and in the room for reactor pressure vessel inspection during operation (closed doors are needed for shielding but they must not be locked to hinder spreading of the main corium part in case of an accident).

VVER-1000/V-320 power units: the measure has been completed (design analysis of the core melt behavior beyond the reactor vessel has been performed, plugs made of heat-resistant material have been installed in channels of NFMS ionization chambers which are the weak spot in prevention of the core melt leak beyond the containment due to insufficient thickness of concrete between the reactor vault and channels of NFMS ionization chambers).

The measure has been completed for all NPP units.

Item 18. "Implementation of a containment hydrogen control system for beyond design-basis accidents"

This measure is intended to implement a hydrogen control system in the containment to ensure continuous monitoring and recording of hydrogen concentration (including post-accident period), which shall comply with qualification requirements for operation during design-basis and beyond design-basis accidents with loss of primary coolant and under seismic events.

The measure has been completed for all NPP units.

Item 19. "Development and implementation of hydrogen mitigation measures for beyond design-basis accidents"

This measure is intended to install passive autocatalytic hydrogen recombiners in the containment for safe mitigation of hydrogen during design-basis and beyond design-basis accidents leading to severe core damage.

The measure has been completed for ZNPP-1,2,3,4,5,6; RNPP-3,4; KhNPP-1,2; PNPP-1,2,3;

Schedule for RNPP-1,2: 2025 (Postponed because of the full-scale invasion of russia).

Item 20. "Implementation of a containment venting system"

This measure is intended to:

- develop and implement a technical decision on forced filtered containment venting;
- supply and install equipment;
- develop a procedure for emergency containment venting in case of a severe accident, amend severe accident management guidelines.

In development of the system design, it is necessary to:

- perform appropriate calculations to confirm the effectiveness of containment pressure decrease, effectiveness of filtration of the vented medium, taking into account the need to minimize radioactive contamination of the environment;
- ensure that the system remains operational in station blackout conditions.

The concept for implementation of this measure was developed by the operating organization and agreed by the SNRIU; pilot power units are PNPP-1 and ZNPP-1.

The design of PNPP-1,2 systems provides for 'dry' filtration of the steam/gas mixture with location of filters in the containment. These systems use combined filters whose housings include two types of filter material: one (metal fibers) for retention of aerosols and the other (silver-doped zeolite sorbent) for retention of radioactive iodine.

The measure has been completed for PNPP-1,2.

Two-stage filtration systems are under implementation at ZNPP-1,2,3,4,5,6, RNPP-3,4, KhNPP-1,2 and PNPP-3. These systems use filters (Venturi scrubbers) including two types of filter material: one (cleaning mixture) to retain aerosols and radioactive iodine and the other (metal fibers) to finely filter aerosols that may remain after the first stage.

To date, the measure has been completed at ZNPP-1,2,4,5, RNPP-3,4, KhNPP-1,2, PNPP-3.

At ZNPP-3,6, the scrubber equipment has been mounted, tests remain to be performed, completion of the measures is postponed until ZNPP is de-occupied.

Schedule:
ZNPP-3,6: 2025 (Postponed because of ZNPP occupation).

RNPP-1,2: 2025.

Item 21. "Analysis of the strategy for possible corium confinement within the reactor pressure vessel"

VVER-1000: A guideline for analysis has been developed and a list of representative severe accidents has been cross-verified, selected and justified. Reports with analysis of the strategy for corium confinement in the VVER-1000 (V-320 and VB-302,338) pressure vessel in severe accidents were developed. Currently, the analytical reports are being revised to take into account international studies under the IVMR HORIZON-2020 program. Currently, no country in the world has implemented a strategy for corium confinement within the VVER-1000 pressure vessel in severe accident progression. In most cases, the attempts to solve this problem are reduced to reactor vessel cooling from the outside and cooling water supply to the core melt (in-vessel). First of all, this is due to the complexity of this activity, lack of experimental studies of certain phenomena of severe accidents at NPPs with VVER reactors, lack of reliable confirmation of the correctness of heat transfer coefficients for internal and external walls of the reactor vessel, unsolved problems with containment heat removal and difficulties with acceptance of a number of simplifications/assumptions for calculational justifications that introduce significant uncertainty into the final results determining further actions on severe accident management. For a long time, international organizations such as the Nuclear Research Institute (Řež, Czech Republic), and others conduct experimental studies aimed at identifying technical solutions on melt confinement inside the VVER-1000 pressure vessel. The studies have not been completed yet. In view of uncertainties in the results of calculations caused by the lack of experimental data and results of international studies, the timeframes for the measure have been extended to **2025**.

VVER-440 RNPP-1,2 (V-213): the measure has been completed. Based on the analysis, the possibility to implement the strategy for corium confinement inside the reactor pressure vessel through the implementation of a reactor ex-vessel cooling system was determined and new C(I)SIP measure No. 31103 "Implementation of Reactor Ex-Vessel Cooling System" was developed for RNPP-1,2. More detailed information is provided in item 33.

Item 22. "Analysis of the need and possibility to qualify power unit components that may be involved in severe accident management for harsh environments"

This measure is performed in the framework of C(I)SIP measures No. 10102, 20102, and 30102 "Analysis of the need and possibility to qualify power unit components that may be involved in severe accident management for harsh environments".

Components of power unit systems that may be involved in severe accident management must be qualified for harsh environmental conditions that can be caused by a severe accident.

For the implementation of this measure, a list of the components that can be used during severe accident management and that are subject to qualification for harsh environmental conditions was developed and agreed with the SNRIU.

The following was developed based on this list:

- Report on assessment of the initial qualification of NPP equipment for harsh environments used in severe accident management.
- Work program on equipment qualification for harsh environments induced in case of a severe accident for NPP units, PM-T.0.41.467-21.

Both documents are currently being revised based on the SNRIU comments.

The option for upgrade of qualification for non-qualified equipment will be selected after assessment of qualification status (if necessary).

Schedule: 2025.

Item 23. "Detailed analysis and development of conceptual solutions on management with large volumes of contaminated water"

The following tasks are performed to implement the measure:

- analysis of international experience in the management of large volumes of radioactive water as a result of severe accidents and experience in implementation of appropriate measures by the operating organizations based on the stress test results (ENSREG);
- identification and justification of representative severe accident scenarios for further computer analysis, considering personnel actions in accordance with severe accident management guidelines;
- calculational analysis of radioactive water accumulations for representative scenarios of severe accidents for three power unit designs with VVER-1000/320, VVER-1000/302 and VVER-440/213;
- determination of the volume, activity, nuclide composition and accumulation dynamics of radioactive water;
- assessment of monitoring tools for radioactive water that may be generated as a result of a severe accident and the potential for confinement of radioactive water under different scenarios;
- analysis of the sufficiency of existing storage and treatment systems for liquid radioactive waste at NPP sites and determination of the need for additional tools;
- development of a conceptual decision for the management of large volumes of liquid radioactive waste considering site-specific features. In addition, the development of measures that are recommended to be implemented at operating NPPs as part of safety improvement, as well as measures that can be implemented in hypothetical initiation of a severe accident.

The following activities have been completed:

- report "Technical Guideline for Assessing the Volumes and Characteristics of Radioactive Water That Can Be Generated in Severe Accidents" was developed and agreed with the SNRIU, with the identification of steps, basic assumptions, computer tools and methods for assessing the volumes and characteristics of radioactive water that can be generated in case of severe accidents;
- "Computer Analysis of Radioactive Water Accumulation during Severe Accidents and Assessment of the Capabilities of the Existing Radioactive Waste Management Systems at NPP Sites" ZV-T.41.23.007-23 was developed and submitted for approval to the SNRIU (letter No. 01-19924/41 dated 4 October 2023);
- KTR-M.0.41.378–23 Project "On the Management of Large Volumes of Radioactive Water That Can Be Generated during Severe Accidents" was developed to be agreed with NPPs.

The deadline for implementing the measure has been postponed until the end of 2024.

Item 24. "Seismic evaluation of buildings and systems of the on-site emergency center and their robustness in severe accident conditions"

PNPP site: **completed in 2016** (seismic resistance of structures, systems and component of the on-site emergency center is ensured at seismic load intensity of 0.16 – 0.18g).
ZNPP site: completed in 2020 (seismic resistance of structures, systems and components of the on-site emergency center is ensured at seismic load intensity of 0.17g).

KhNPP site: completed in 2021 (seismic resistance of structures, systems and components of the on-site emergency center is ensured at seismic load intensity of 0.1g).
RNPP site: **completed in 2021** (seismic resistance of structures, systems and components of the on-site emergency center is ensured at seismic load intensity of 0.1g).

Item 25. "Analysis of severe accident phenomena based on available experimental data and improvement of computer models"

The operating organization developed and implements "The Work Program on Analysis of Severe Accident Emergency Phenomena" PM-T.0.41.414-21. The work in the following areas is carried out within the Program:

- analysis of in-vessel phenomena of severe accidents;
- analysis of ex-vessel phenomena of severe accidents;
- analysis of "specific" phenomena in severe accident progression;
- comprehensive analysis of severe accident phenomena;
- justification (specification of justifications) of post-Fukushima measures;
- specification of SAMG development results;
- development (specification) of measures related to emergency preparedness and response;
- purchase/update of computer code versions;
- improvement/adaptation of existing computer models to updated versions of software tools.

Analysis of international experience for studying the severe accidents phenomena was conducted; as a result of the analysis, an experimental data matrix based on the existing experiments was developed. The development of this matrix provided an experimental basis for further investigation of severe accident phenomena and correction of the computer models used in the development of EOPs and SAMGs and, if necessary, for the development of new models.

The study of probable criticality initiation in severe accident progression refers to "specific" phenomena and is at the final stage. In particular, the reactor and SFP model for pilot power units (PNPP-1, ZNPP-1, RNPP-1) has been developed for the MCNP computer code and calculational analysis of changes in neutron-multiplying properties of fuel-containing masses at different stages of severe accidents inside the reactor and SFP has been performed. Currently, the developed documents are being finalized based on SNRIU review.

Activities on other Program implementation stages are ongoing and scheduled to be completed **by the end of 2026**.

Additional Topics and Activities

Item 26. "Harmonization of Ukrainian nuclear and radiation safety regulations with WENRA reference levels":

a) self-assessment;

b) development of a harmonization action plan

In order to implement this measure, the SNRIU:

- carried out self-assessment for compliance of national nuclear safety regulations with the "WENRA Reactor Safety Reference Levels 2008" in the framework of the EC technical assistance project and conducted peer review of the self-assessment involving experts from regulatory authorities of Czech Republic, Slovakia, Finland and Bulgaria;

- performed self-evaluation of national NRS regulations for compliance with the updated WENRA reference levels for existing reactors (WENRA Safety Reference Levels for Existing Reactors. Update in

relation to lessons learned from TEPCO Fukushima Dai-Ichi accident) and conducted peer reviews within SNRIU participation in WENRA RHWG activities with all WENRA RHWG member states.

The measure has been completed.

The results of the above activities are considered by the SNRIU in the annual plans of rule-making activities of the regulatory body.

In the period from 2015 to 2021, the SNRIU developed and approved a number (more than 15) regulations and rules on nuclear and radiation safety, including that for implementation of the WENRA reference levels for existing reactors, in particular, regarding the safety management system, safety analysis and safety review of nuclear installations, natural hazards, emergency preparedness, long-term operation and aging management, risk-informed approach, etc.

In addition, in connection with the publication of the revised WENRA Safety Reference Levels for Existing Reactors in February 2021 (Report. WENRA Safety Reference Levels for Existing Reactors 2020, ed. 17 February 2021), the SNRIU conducted self-evaluation of current Ukrainian legislation on nuclear energy use for compliance with the updated WENRA reference levels. According to the self-evaluation schedule, the final results of the self-evaluation and the corresponding action plan to improve the legislation of Ukraine are expected in early January 2022.

Item 27. "Self-assessment of the nuclear safety regulation system using the new IAEA instrument – SARIS"

In 2014, self-evaluation of the system for regulation of nuclear and radiation safety was conducted using SARIS. A self-evaluation report was generated upon summary and verification of the system.

The measure has been completed.

Self-assessment of the nuclear safety regulation system using the new IAEA instrument SARIS is carried out by the SNRIU on a systematic basis: persons responsible for different regulatory areas are appointed, questionnaires are updated in the light of new IAEA publications.

In particular, results of self-assessment in the emergency preparedness and response area for compliance with IAEA GSR Part 7 were used in revision of the national plan of response to nuclear and radiation accidents in 2019.

In 2021, a new version of the new IAEA instrument, SARIS, was released. SNRIU staff took part in relevant exercises.

Item 28. "Provision of mobile laboratories to ZNPP and PNPP"

PNPP site: **completed**.

ZNPP site: activities are ongoing in the framework of C(I)SIP measure 14401 (ARMS). An ordering plan was concluded for the manufacture and supply of ARMS equipment; supply and commissioning of two mobile radiological laboratories based on off-road vehicles were planned for **2023**. However, due to ZNPP occupation by russia, the measure was postponed to the period after ZNPP de-occupation.

Item 29. "Development of the concept and plan for the unified state automated radiation monitoring system of Ukraine (UARMS)"

Pursuant to the measure, the "Strategy for the Integrated Automated Radiation Monitoring System for the Period by 2024" and "Operational Plan for the Implementation of the Strategy for the Integrated Automated Radiation Monitoring System for the Period by 2024" (Operational Plan) were developed and approved by Cabinet Resolution No. 323-r dated 29 April 2022.

The implementation of Project U4.01/19 "Support in the Development of an Integrated Automated Radiation Monitoring System Covering the Entire Territory of Ukraine" is ongoing.

The implementation of C(I)SIP measure No. 14408 "Integration of NPP ARMS into a Unified Automated Radiation Monitoring System" is scheduled to be completed in 2025 (Postponed because of ZNPP occupation and full-scale invasion of russia).

Functions of the state system of environmental radiation monitoring are performed by hydrometeorological posts of the Ukrainian Weather Center of the State Emergency Service of Ukraine, whose activities are coordinated by the Minister of Internal Affairs of Ukraine.
Within the framework of European Commission projects, the Ukrainian Weather Center established a center for forecasting the consequences of radiation accidents that constantly collects, processes and analyzes hydrometeorological information and data on contamination levels and radiological condition of the environment and uses modern tools to model the spread of radioactive contamination in the environment, including the JRODOS automated decision support system. Since 2016, the Ukrainian Weather Center transmits data from Ukraine on the gamma dose rate to the Joint Research Center of the European Commission for further coverage on the International Radiological Data Exchange Platform (EURDEP). Information can be found at https://remap.jrc.ec.europa.eu/GammaDoseRates.aspx

Item 30. "Long-term (more than 24 hours) emergency training for all response parties, including central executive authorities, to test the knowledge transfer procedure in conditions of shift work of emergency staff"

Completed.
These long-term exercises are conducted in Ukraine annually at one of the NPPs in compliance with the schedule agreed by the SNRIU.
For example, general plant full-scale emergency exercises were conducted at:

- Pivdennoukrainsk NPP, 23-24 May 2018, scenario of a general accident with partial damage of the Unit 3 core involving total station blackout;
- Zaporizhzhia NPP, 14-15 November 2018, scenario of a general accident at Unit 3 with radioactive release beyond the designed boundaries caused by SG-1 leakage, failure to close SG SV TX50S03 and a number of ECCS failures;
- Pivdennoukrainsk NPP, 09-10 June 2021, scenario of a general accident at PNPP involving total station blackout with a failure of all diesel generators at Unit 2 and primary-to-secondary coolant leakage with opening of BRU-A (steam dump value to atmosphere) of the emergency steam generator at Unit 3.

The planned common-plant exercises were not conducted in 2019 (Khmelnytsky NPP) and in 2020 (Rivne NPP) because of upgrading of the KhNPP full-scope simulator and quarantine restriction on mass events.

In the framework of the action plan for the functional subsystem 'Nuclear and Radiation Safety' of the Unified State Civil Protection System and Ukraine participation in international ConvEx exercises, the procedures for interaction with other central executive bodies and departments that participate in measures of emergency response to nuclear and radiological incidents within their competencies and obligations (agreements) on interaction with the SNRIU, particularly the State Emergency Service of Ukraine, Security Service of Ukraine, Ukrainian Weather Center, Ministry of Health of Ukraine, State Service of Ukraine on Food Safety and Consumer Protection etc., will also be tested and verified at national and regional levels.
2018: Ukraine participated in four IAEA emergency exercises: ConvEx-1a (25.04.2018), ConvEx-1c (18.07.2018), ConvEx-1b (04.09.2018), ConvEx-2c (27.11.2018).
2019: Ukraine participated in six IAEA emergency exercises: ConvEx-2a (12.06.2019), ConvEx-2b (26-28.03 2019), ConvEx-1a (19.01.2019), ConvEx-1c (29.05.2019), ConvEx-1b (15.07.2019), ConvEx-2d (23-24.10.2019).
2020: Ukraine participated in five IAEA emergency exercises: ConvEx-2a (12.05.2020), ConvEx-2b (24-26.03.2020), ConvEx-2c (09.12.2020), ConvEx-1a (14.10.2020), ConvEx-1b (10.03.2020).
2021: Ukraine participated in two IAEA emergency exercises: ConvEx-2b (09-11.03.2021) and ConvEx-2a (27.05.21) and two exercises common with the Norway regulatory body (DSA) on 25.03.21 according to the scenario of a conditional accident with loss of control over a radiation source on the territory of

Ukraine/Norway and on 22.04.2021 according to the scenario of a conditional accident at a nuclear facility on the territory of Ukraine.
SNRIU experts also took part in two common exercises with radiological reconnaissance mobile laboratories of Germany and Ukraine within the project of the Federal Office for Radiation Protection of Germany (BfS) and State Specialized Enterprise "Ecocenter" in the exclusion zone with assistance of the German Embassy in Ukraine (30.08.2018-11.09.2018 and 04-19.09.2021). The current radiological parameters of the Chornobyl exclusion zone were measured, modern techniques of airmobile radiation reconnaissance and skills in using portable and mobile equipment were tested, transmission channels and compatibility of measurement results, behavioral culture in actual radiological conditions and interaction procedures in response to nuclear and radiation situations were verified.
On 14 September 2022, plant emergency exercises were conducted at Khmelnytsky NPP on the topic "General accident caused by a military emergency, which led to a loss of in-house power supply at Unit No. 1."
On 29-30 June 2023, command and staff training with the involvement of the interested central and local executive authorities to test actions in the event of a radiation accident at the Zaporizhzhia NPP under conditions of temporary occupation by armed forces of the russian federation was arranged and conducted in the Emergency Center of the Energoatom Company by the Ministry of Energy of Ukraine in order to check preparedness of the Energoatom Company to respond to a radiation accident at the Zaporizhzhia NPP under occupation of the russian federation and to practice interaction with governmental bodies and forces of functional and territorial subsystems of the unified state civil protection system, involved in responding to a radiation accident at the Zaporizhzhia NPP together with the Energoatom Company.
On 20 July 2023, the civil protection management bodies of the territorial subsystem of the unified state civil protection system in the Khmelnytsky region jointly with Khmelnytsky NPP conducted command and staff training on the topic "Actions of the management bodies and civil protection forces of the territorial subsystem of the unified state civil protection system in the Khmelnytsky region in a radiation accident at Khmelnytsky NPP caused by russia's military aggression against Ukraine".
On 11 July 2023, the civil protection management bodies of the territorial subsystem of the unified state civil protection system in the Rivne region jointly with Rivne NPP conducted command and staff training on the topic "Actions of the management bodies and civil protection forces of the territorial subsystem of the unified state civil protection system in the Rivne region in case of a radiation accident at Rivne NPP caused by russia's military aggression against Ukraine".
16–17 August 2023, the civil protection management bodies of the territorial subsystem of the unified state civil protection system in the Mykolaiv region jointly with PNPP conducted command and staff training on the topic "Actions of the management bodies and civil protection forces of the territorial subsystem of the unified state civil protection system in the Mykolaiv region in case of a radiation accident at PNPP caused by russia's military aggression against Ukraine".
In accordance with Energoatom Order No. 01-3-n "On the general plant emergency response training at Rivne NPP jointly with the Energoatom Directorate" dated 2 January 2023, joint Energoatom and SNRIU general plant emergency response training on the topic "General accident at Rivne NPP caused by blackout at Units No. 1, 2 as a result of a missile attack of russia on the energy infrastructure facilities in the energy system of Ukraine and Rivne NPP" is planned for 15-16 November 2023.

Item 31. "Implementation of the RODOS system"

Completed.
On 30 June 2016, the RODOS decision support system was officially presented in Ukraine at the State Emergency Service of Ukraine with participation of representatives from the European Commission, SNRIU, Energoatom Company, National Academy of Sciences of Ukraine and other agencies.

The RODOS decision support system was introduced into commercial operation in January 2017.

In 2018:

- the RODOS decision support system was extended to the Chornobyl exclusion zone;
- the "Methodology for Preparation of Input Data and Assessments and Prediction of Accident Consequences Using the RODOS Decision Support System" was implemented at SNRIU Information and Emergency System.

In 2019:

- internal training workshop "Preparation of Input Data on the Source Term for Evaluation of Radiological Consequences of NPP Accidents Using the RODOS Decision Support System" was performed on 21 February 2019;
- prompt assessment of the risk and transboundary impact of the incident that occurred on 8 August 2019 in the Russian Federation at a military test site on the coast of the Dvina Bay of the White Sea (Nenoksa) and was accompanied by human casualties and short-term increase in radiation background according to automated radiation monitoring systems was carried out.

In 2020:

The JRODOS decision support system was used by the Information and Emergency System staff in responding to actual events that did not have a direct impact on the safety of nuclear installations and activities in the area of nuclear energy, but caused increased media attention and public concern and required appropriate information, in particular, prompt assessment and notification of the Cabinet of Ministers of Ukraine and National Commission for Radiation Protection, in particular, in connection with fires in natural ecosystems in the exclusion zone, which lasted from April to May 2020, when atmospheric dispersion modeling and radiation impact assessment were performed on a permanent basis.

EC INSC Project U3.01/18 (UK/TS/58) "Assistance to the regulatory body of Ukraine", task H2 "Implementing the HERCA-WENRA approach to improve interstate coordination of protective actions during nuclear accidents" was implemented through:

- review of the implementation status of the JRODOS decision support system at SNRIU IEC and identification of existing gaps in the context of collecting and preparing data necessary for modeling and interpretation of relevant results;
- development of requirements for completeness and format of initial data necessary for radiation impact assessment using the JRODOS decision support system at SNRIU IEC, improvement of information exchange with other platforms or systems (ECURIE, USIE, IRMIS) taking into account European experience;
- comparison of the results from atmospheric dispersion modeling and prediction of radiation doses of the public based on several emergency models using a chain of models for local transport of the JRODOS decision support system (RIMPUFF, DIPCOT and LASAT) and provision of recommendations for their use by SNRIU IEC experts.

In 2021:

On 17 March 2021, experts of the SNRIU and State Emergency System of Ukraine took part in the annual international meeting of the RODOS decision support system user group in online format. Examples of JRODOS application in the EU countries and in Ukraine were considered. Experts from the Karlsruhe Institute of Technology (KIT) presented information on new JRODOS developments, including those upon NATO request.

On 30-31 March 2021, training was held for the Ukrainian JRODOS users (SNRIU, SSTC NRS, Ukrainian Weather Center, State Agency of Ukraine on Exclusion Zone Management, Energoatom) within EC Project UK/TS/58.

In 2022-2023:

Starting from the full-scale invasion by russia, daily calculations have been performed with RODOS DSS to predict consequences of radiation accidents at the Rivne and Zaporizhzhia NPPs. The most severe scenario of event progression is taken as an initiating event. Activities are currently underway to

prepare for the conclusion of contracts for technical support of the system by the developer and for training of additional Energoatom personnel.

Item 32. "Modernization of the SNRIU Emergency Response and Information Centre"

The SNRIU Information Emergency Center (IEC) was modernized under an infrastructural project within the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction with support of the Defense Threat Reduction Agency of the U.S. Department of Defense from July 2016 to December 2017. Within the IEC modernization project, the system for communication with NPPs was replaced, power supply system was replaced (including repair of the standby power source, diesel generator), IEC computer equipment and software were updated, etc.

Establishment of a standby emergency center was not considered in this project.

Completed.

Item 33. "Implementation of a reactor pressure vessel external cooling system"

Upon implementation of the C(I)SIP measure "Analysis of the Strategy for Possible Corium Confinement within the Reactor Pressure Vessel' for VVER-440, new measure No. 31103 'Implementation of a Reactor Pressure Vessel External Cooling System" was introduced for RNPP-1,2. Company VUEZ a.s. supplied a RPV external cooling system for RNPP 1, 2.

The event is taken in stages:

As part of Stage 1, the RPV external cooling system was implemented at RNPP-1,2.

As part of Stage 2, the system for long-term heat removal from the containment will be implemented, hydrogen safety during severe accident progression will be analyzed, and an additional venting line from the primary system will be installed. Stage 2 will be conducted in stages until the end of 2025 (taking into account the martial law in Ukraine).

Section 2. Status of Measures Identified upon Stress Tests at Chornobyl NPP

This Section provides information on the status of measures identified upon stress tests at Chornobyl NPP and presented in Table 1.2 of Part IV "Plan for Implementation of Safety Improvements" of the National Action Plan upon Stress-Test Results (2013).

Item 1. "Installation of an additional level control device in 1 (2) fuel assembly cooling pools-1, 2 for emergencies related to level water decrease below marks 19, 22"

Completed (in 2012)

Additional control of water level to prevent its potential emergency decrease is ensured in the spent fuel pools of units 1 and 2.

Item 2. "Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under loads induced by a tornado of class F 3.0"

Completed (in 2016)

The ISF-1 building and overpass structures between the solid and liquid waste storage facility and ISF-1 were examined and certified in 2015. The defects revealed in structures were eliminated during 2016. Calculations of ISF-1 building and overpass structures between the solid and liquid waste storage facility and ISF-1 for a combination of loads including seismic events of 7 magnitudes (which is higher than SSE) and tornado of class F 3.0 have shown that the resistance of ISF-1 load-bearing structures under the above events will be ensured.

Item 3. "Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under seismic loads"

Completed (in 2013)

Calculations of ISF-1 structures related to nuclear safety category 1 testify that ISF-1 SFP civil structures can resist seismic events of 7 magnitudes (MSK-64 scale), while the safe shutdown earthquake for the ChNPP site is 6 magnitudes.

Item 4. "Seismic resistance analysis of ISF-1 SFP lining"

Completed (in 2013)

Calculations of ISF-1 SFP lining testify that it can resist seismic events of 7 magnitudes (MSK-64 scale), while the safe shutdown earthquake for the ChNPP site is 6 magnitudes.

Item 5. "Analysis of stability and potential failures of VS-1 (ventilation stack for units 1 and 2) under SSE and tornado"

Completed (in 2014)

Inspections and analyses of ventilation stack VS-1 justified its lifetime extension for 20 years as it will be able to resist a seismic event of 6 magnitudes (safe shutdown earthquake) and a tornado of class F 1.5. This is acceptable because units 1 and 2 are radwaste management facilities.

Item 6. "Nuclear safety justification for the spent fuel pools of units 1, 2 with 250×110 mm arrangement of SFAs (as reserve for one ISF-1 compartment)"

Completed (in 2012)

Nuclear safety justifications using the burnup credit approach for SFPs of units 1 and 2 allowed determining the arrangement of SFAs in SFPs of units 1 and 2 if emergency unloading of one of the ISF-1 SFP compartments is required.

Item 7. "Justifying calculation of the maximum fuel cladding temperature taking into account potential radiological consequences from wet SFA storage"

Completed (in 2013)

Additional analysis of fuel cladding cooling in ISF-1 storage conditions was carried out.

Item 8. "Development of an action plan to improve the emergency preparedness system in case of beyond design-basis accidents caused by natural hazards, including emergency response measures in case of damage of the building and leakage of SFP"

Completed (in 2012)

Emergency notification procedures and emergency response actions in case of potential structural collapse were improved.

Item 9. "Amendment of the ChNPP accident and emergency response plan (32P-S) to improve emergency preparedness"

Completed (in 2012)

Based on analysis of natural hazards, the ChNPP accident and emergency response plan was revised as appropriate.

Item 10. "Development of measures on prompt access of emergency teams from Slavutych by alternative routes in case of damage of Slavutych–ChNPP railroad tracks caused by SSE"

Completed (in 2012)

Procedure for delivery of emergency team personnel by motor vehicles from Slavutych to ChNPP (as alternative routes relative to railroad transport) was developed and implemented.

Item 11. "Modernization of the ISF-1 radiation monitoring system to ensure neutron flux density monitoring"

Completed (in 2012)

Neutron flux density monitoring (within the radiation monitoring system) is envisaged for process rooms and areas for management and storage of spent nuclear fuel.

Item 12. "Additional radiation monitoring of exposure dose rate of the container car in ISF-1 during spent fuel transport"

Completed (in 2012)

Additional detectors for monitoring of exposure dose rate were installed in the container car storage area in ISF-1 building.

Item 13. "Replacement of the UDZhG-04R detector with an RWM-02 detector for the instrumentation channel for monitoring the activity concentration of service water after heat exchangers in ISF-1 spent fuel pools"

Completed (in 2013)

Implementation of RWM-02 detector also provides for monitoring of radionuclide activity in service water supplied to ISF-1, thus allowing the contribution of ISF-1 to the total ChNPP discharges to be calculated.

Item 14. "Power supply to ISF-1 essential equipment fed from mobile DG"

Completed (in 2011)

The mobile DG is placed on the ChNPP site and is ready to be connected to ISF-1 in-house power supply system.

Item 15. "Purchase of a new container car for SFA transport"

Completed (in 2018).

A railroad container car was delivered to ChNPP for transport of packaging with spent nuclear fuel. Acceptance tests of the container car were performed. The packaging was certified.

Item 16. "Revision of the ISF-1 safety improvement plan"

Completed (in 2012)

The ISF-1 safety improvement plan was revised to remove measures that had been already completed and analyzed in the ISF-1 safety analysis report.

Item 17. "Introduction of the topic "multiple failures of regular systems and equipment in severe weather conditions" into the 2012 training program for ChNPP staff of certain positions for detailed theoretical elaboration of the training scenario"

Completed (in 2012)

Item 18. "Introduction of the topic "multiple failures of regular systems and equipment in severe weather conditions" into the 2012 training program (Section 14) for practical exercise by staff of all shifts"

Completed (in 2012)

Item 19. "Psychological training of staff intended to increase resilience to psychological stress, develop self-control, composure and promote mutual aid and cooperation"

Completed (in 2012)

Training on the psychology of actions in extreme situations was introduced on a systematic basis for relevant groups of personnel.

Item 20. "Implementation of a system for psychological selection and training of individuals involved in severe accident management, similar to the system for selection of operating personnel"

Completed (in 2012)

Psychological examination of emergency team leaders is underway.